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Federal Communications Commission
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**Comments to MM Docket No. 94-131**
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INTRODUCTION - Marshall Communications, Inc. (MC) is a small consulting firm specializing in computerized MMDS, ITFS & LPTV interference analyses, MMDS station design and in the preparation of FCC applications for builder/operators in the MMDS industry. MC has spent a considerable amount of time in developing improved MMDS interference analysis techniques and in developing specialized software to efficiently conduct analyses using the improved techniques. The improved methods present much greater amounts of information and conduct substantially more rigorous analyses, yet present the results in an intuitive, graphical format specifically intended to be easy for the Commission to evaluate. As a result of this development work and experience in conducting interference analyses, MC has become intimately familiar with the problems associated with MMDS interference and has firm, well-thought-out opinions pertaining thereto. Since certain of the proposals set forth in the NPRM, if adopted, would promote the potential for harmful interference, MC considers it appropriate to comment in considerable detail about the consequences certain proposals in the NPRM would have upon the MMDS industry. Comments and proposals are presented, that, if adopted, would expedite application processing, reduce harmful interference and enable the Commission to better serve the public interest.

It is apparent to one skilled in the calculating harmful interference that certain of the proposals set forth in the NPRM ignore technical considerations and the public interest altogether, rather are presented only from an administrative point of view with the singular intent of easing the Commission's burden of application processing. I strongly urge the Commission to *very* carefully consider the technical aspects of the instant proceeding as discussed herein (and as commented on by other technically qualified commenters) to avoid adopting arbitrary rules intended to expedite application processing that will, in reality, only create a different set of problems while side stepping many important issues that need to be addressed by the Commission. In short, MMDS rules should be based upon technical considerations first and administrative exigencies second. Regrettably, it seems that the NPRM approach is the other way around. Specifically stated in the NPRM, is that comments are restricted to those related to application processing. Since some proposals in the NPRM, if adopted, would create intolerable interference problems, technical considerations cannot be ignored. They are discussed with the intent of conveying a clear and concise understanding to the Rulemakers the effect certain proposals in the NPRM would have on the MMDS industry. If this endeavor is successful, hopefully only technically sound proposals will be adopted. The following comments are referenced to the specific paragraph numbers in the NPRM.

7. ***MSA/RSA/ADI Approach*** - While the concept of geographically predetermined filing areas for MMDS may be appealing from an administrative point of view, it has no merit whatsoever from a technical perspective. The conclusion that, "because such an approach worked so well for cellular it ought to be applied to MMDS" is a totally erroneous conclusion reached only by ignoring technical considerations. Once the difference between the signal modulation/demodulation properties of two respective services is understood, it becomes clear that the two cannot be equated.

Since MMDS signals are amplitude modulated their interference products add linearly in the receiver detector; this dictates that co-channel interference criteria to be quite strict, 45 dB. Expressed in linear terms, this is a factor of 31,623:1 (631:1 for 28 dB, as used with offset, an improvement of 50:1). Whereas, cellular uses a different modulating technique that allows a signal only slightly greater in amplitude than the interfering signal to be captured by the properties of the receiver, while the weaker signal is ignored altogether. In simple terms, the interference protection criteria is upwards of 30,000 times greater for MMDS than for cellular ($\approx$600 X with offset). A similar, though less dramatic effect, is realized with digital transmission. Due to the nature of analog MMDS signals, i. e., the requirement for line-of-sight signal path and a very high degree of interfering signal attenuation, it follows that, from a technical perspective, there are only two relevant factors that dictate the proper location of MMDS stations, and these are demographics and topography, period. Of course other parameters such as polarization, EIRP, antenna pattern/orientation, etc. are relevant in station design and interference analyses, but can be specified in the design, therefore, are of secondary importance in assessing where an MMDS station should be located.

Regarding separation standards, it doesn't matter whether the stations are separated ten miles, fifty miles or a hundred miles. The only consideration is whether terrain totally shields the area(s) of potential interference (API). (The API concept is thoroughly explained in Appendix B). Consider two stations of Equal EIRP, same polarization, with both having 15 mile radius PSAs. When unobstructed electrical paths exist into the area directly behind one station, a station separation of 2,652 miles is required to attain a 45 dB D/U ratio at PSA) edge. Clearly, this is an impossibility due to earth curvature. However, it clearly illustrates that, at MMDS distances, harmful interference will be substantial and that the requirement exists for total terrain shielding over parts of a stations protected service area at normal distances, actually over most of the PSA in same polarized stations. If cross polarized this distance is reduced to 253 miles. With offset and same polarization using 28 dB D/U criteria the distance is 362 miles. Taking this into consideration, it becomes obvious that the API must be completely terrain shielded from the interfering signal. If this area is in the middle of town, serious interference problems will occur. Once the concept is fully understood, it becomes obvious that an effective method to identify the API becomes more importance as station spacings decrease. This is addressed elsewhere and in Appendix B. In contrast, in some areas, stations may be located on opposite sides of a mountain, only a few miles apart, yet neither will cause harmful interference to the other. Separation standards are of relevance only in relatively flat or gently rolling terrain where the earth curvature provides terrain shielding.

Additionally, it would lead to other irreconcilable situations. For instance, consider Rochester, Minnesota. Here is a small MSA a few miles across, surrounded by seven counties comprising an RSA. While this presents no particular problems for cellular type signals, it presents insurmountable problems for two MMDS stations, due to the requirement for the very high degree of signal isolation required by MMDS. Clearly, in this case, applying the RSA boundaries to MMDS would be totally inappropriate, indeed would be ludicrous. In this particular case the MSA and the RSA should be served by one station.

*ADI* - Since the MSA approach has been pursued since 1983 and most MSA licenses are pending or granted, switching midstream to the ADI approach would only throw an unnecessary confusion factor into the mix. This makes absolutely no sense at all. Perhaps in 1983 it would have had some merit, but not now.

In conclusion, the geographically predetermined filing area approach is counterproductive to satisfying the essential topography shielding requirements of MMDS extant in many parts of the country. The public interest will best be served by strategically locating stations to serve the maximum number of households with the minimum amount of harmful interference. This is best accomplished with the minimum number of strategically located stations required to adequately cover populated areas. Geographically predetermined filing areas cannot accomplish these objectives. Its adoption would effectively tie one arm of MMDS behind its back. Since interference standards are so critical for MMDS, it follows that the only rational approach is to require that applications be rigorously engineered to demonstrate, beyond a shadow of doubt, that harmful interference will not occur from the operation of a proposed station. Therefore, based on technical reasons, I am opposed, to any kind of predetermined geographic filing area approach for MMDS. Its adoption would likely create problems of a more serious nature than the administrative burden it was intended to alleviate. Since it is so abundantly clear that the MSA boundary rules have stifled the development of MMDS in many large MSAs, why further compound this error by adopting RSA boundaries. Quite simply, there is no magic bullet that will miraculously solve the Commission's application processing problems without having detrimental effects on the MMDS industry.

8. *15 Mile Radius PSA in Conjunction with MSA/PSA/ADI Approach* - Since I do not agree that the MSA/RSA/ADI approach is acceptable, for technical reasons, whether the PSA is 15 mules or the unit boundary is a moot point from my perspective. If such an approach is adopted and the boundary adopted to be the PSA, then the current Rules would be woefully inadequate to provide interference protection and, since the benefits afforded by terrain shielding would be considerable minimized, perhaps they would be inadequate even with the 15 mile PSA.

In the event a predetermined boundary approach were to be adopted, to help alleviate the effects of harmful interference, it would be mandatory for the Commission to simultaneously adopt the requirement for all existing stations to specify and use precise frequency control such that newly proposed stations can utilize offset techniques. But then, I believe this should be adopted into the Rules in any case, as the need for its use will become more of a necessity as station density increases. This should be done immediately, before fill-in stations are authorized and interference becomes intolerable at worst, or extremely hard to deal with at best. Low Power TV has already dealt with this matter and routinely allows offset techniques to mitigate the effects of harmful interference and so should MMDS, which uses the same modulation technique. A newly proposed station should not have to negotiate with an existing station and offer to reimburse for equipment in order to enjoy the benefits offset provides. Precise frequency control equipment using Loran C with a frequency stability of $\pm 3$ Hz is available at a cost of approximately $7,000 per station, hardly a drop in the bucket, considering the cost of constructing a station. The advantages to the public would far outweigh this small initial cost, in that it would expand the useful service areas considerably and would allow some areas to enjoy interference free reception from more than one station, thus further fostering competition. This would accomplish more for the industry than expanding the present protected service area, as it would enlarge the *useful* service area considerably. Not necessarily in a circular pattern, but with proper station design and area frequency coordination would allow stations substantially larger interference free service areas. Also, since MMDS frequencies are considerably higher in frequency and propagate somewhat differently, the methods used to predict UHF coverage cannot be applied to MMDS. Indeed, I have serious doubts as to their accuracy in predicting UHF coverage and interference.

Some operators dispute that 28 dB with precise frequency control and offset is equivalent to 45 dB without precise frequency control and offset. Some argue that the figure should be 30 dB. Others may argue that 30 db is insufficient. I will not venture an opinion on the exact value, rather will leave that matter to those with more field experience than I.

Perhaps as a starting place, the larger MSA stations and those geographically isolated from other MSAs should be assigned zero offset, or assume it, depending on the mechanism used to assign offset. Smaller, adjacent MSAs, or those in close proximity to the larger MSA would utilize + or - offset, as appropriate. Once offset has been determined and assigned for all MSA stations, the fill-in stations could then intelligently coordinate offset with the predetermined MSA offsets. This would alleviate interference problems considerably and its implementation is not an overwhelming task. Given a wall map showing the MSA boundaries and a marking pen, it should take a bright junior engineer only a few hours to coordinate MSA MMDS offset assignments for the entire country. The results could then be released in a Public Notice that new applicants would use to determine the proper offset for newly proposed stations. Also, it would allow local ITFS stations to operate in much closer proximity to MMDS stations using collocated ITFS channels and MMDS stations to operate in closer proximity to grand fathered E or F channels. In short, there are a host of benefits that would result from such an approach. It is matters such as these that the Commission should be concerning itself, as individual licensees are only concerned with protecting their own licenses and service areas, and have little interest in area wide frequency coordination. Alternately, if the filing window and a first window for existing stations/licensees is adopted, a requirement could be that all MSA stations and other existing stations must specify their offset specification, otherwise it will never happen, as MMDS station operators are generally concerned with keeping neighboring stations as far away as possible. In areas where mountains exist this may be considerable distances and this includes a fair portion of the country. An equally valid argument could be made for polarization assignments, but this is an opportunity the Commission has already let slip by. Also, it is much easier to change a station's offset than its polarization, once the station has been built. An enforced polarization change to an existing station with many subscribers would be an operators worst nightmare come true.

Curiously not mentioned in the NPRM was the effect of the use of digital transmission on harmful interference. By the time the next round of applications are granted and built in areas surrounding existing MSAs, it is likely that digital equipment will be available. New digital stations will surely have to coexist with existing analog stations in many areas for some time to come. For a given EIRP, a digital station will almost certainly interfere more with a analog station than an equivalent analog vs analog station. Whereas, the existing analog station likely will interfere little, if any, with such new digital stations. Since MSA stations, in general, are, or will be built substantially before surrounding stations and most will likely be analog for some time to come, a potential situation could develop where analog MSA stations are surrounded by digital stations. This likely scenario further supports the premise that precise frequency control with provision for offset should, one way or the other, should be adopted as a retroactive standard for all MMDS stations, and should be done in the instant proceeding. Accomplishing this now will greatly expedite adoption and implementation of standards for digital, when it comes about. Such thinking and planning ahead may save six months or a year of debate and delay on adopting digital standards, as it implementation would substantially reduce interference thus making the entire issue less complex.

11. ***E, F and H identified sites*** - Identifying sites available for filing based upon existing E, F or H channels is no guarantee that stations will be located at appropriate sites to construct an MMDS system, as many initial applications were/are filed upon highly arbitrary coordinates. Standard operating procedure, when constructing a new MMDS station, dictates that most existing licenses be relocated to a proper transmit site and collocated with other licenses. Unfortunately, due to various FCC rules, closed windows, etc., this generally requires several rounds of applications, which further adds to the Commission's application processing burden. Also, many H applications were filed by speculators at sites that were not collocated with, and sometimes not even near E or F channels, in order to satisfy an arbitrary 50 mile spacing rule imposed by the Private Radio Bureau. In fact many of the problems that beset MMDS today are the result of inappropriate and largely arbitrary rules that are not consistent among the various channel groups. It is time a set of uniform, cohesive rules based upon sound technical considerations are adopted. This will go farther in promoting MMDS service than all the auctions the Commission can muster, or anything else it can do. Also, there are areas in some of the larger MSAs that are not served, by reason of the MSA rules, that perhaps have sites that will better serve the public interest than some arbitrary license that may have been granted in a lesser adjacent area to a speculator that may well block such stations from ever being built. So, I am not impressed with this idea and I go on record as opposing it.

12. ***National Filing Window Proposal.*** Of the proposals set forth in the NPRM, the window approach with no geographic boundaries makes the most sense, both technically and from a public interest point of view. I believe it would result in better covering populated areas while minimizing harmful interference, as topography and demographics could be fully taken into account and stations locations could be optimized. The concept of eliminating all geographical boundaries (and I presume 50 mile spacing rules) with no geographical restrictions on MDS channels is extremely appealing. The concept of making application for all available MMDS channels in an area would aid operators in assembling channel capacity and would allow sites to be evaluated by the commission as a batch rather than several individual applications. How about ITFS stations in an existing MMDS station area? If existing stations are given preferential treatment to obtain all available MMDS channels, would it not follow that they should have some protection from competing ITFS filers coming into the area and filing competing applications?

13. ***Comments on how to resolve "Daisy Chains"*** - The predetermined MSA boundaries used in the 1983 filings was based upon the rationale that it would eliminate endless "Daisy Chains" of mx applications that would be difficult or impossible to sort out. Though the MSA Rules in general have outlived their usefulness as regards geographical boundaries, a preference relating

to mutual exclusivity should be retained, both to expedite MSA station development and allow them to serve as a mechanism to break up problematic "Daisy Chains". This effectively retains the elements used to justify the MSA approath originally adopted. The primary station in an MSA, whether previously or subsequently licensed or proposed, should take precedence over newly proposed stations in or adjacent to the MSA with regard to mutual exclusivity. Since the public interest is better served by the larger station, the Commission has a valid rationale upon which to base such a rule. This would eliminate the potential for endless Daisy Chains by breaking them into smaller segments in between MSAs. If everyone knows this ahead of time they will engineer proposed stations such that they are not mutually exclusive with existing channels at MSA stations, knowing that the remaining channels will be filed for ASAP and will be given mx preference.

The Commission should reserve some prerogative to make a decision whether a proposed station is properly situated such as to be in the public interest or to perform the stated function and should have the authority to return such applications that are obviously frivolous. This would be preferable to an auction or lottery. The spacing between MSA stations, generally allow a station or two in between, and it is usually readily apparent, with minimal effort, to determine how many stations are necessary to provide adequately service throughout the remaining area. Indeed, it should be a requirement for applicants to demonstrate that a proposed station would be in the public interest by *demonstrating* in the application that the proposed primary service area cannot be served by existing, or previously proposed stations, and also, demonstrate that the service area consists of a sufficient number of potential subscribers to make a station economically viable. This would likely weed out many insincere applications. Just because a proposed station does not interfere with any other previously proposed station does not necessarily justify its existence. No serious builder will file applications in areas that are not economically viable, whereas, the application mills will file anywhere they can squeeze in a station. Also, the mills are not particularly noted for technical excellence. Adopting, more sophisticated engineering requirements are likely to greatly impair their ability to function effectively. For instance, the application mills won't give a second thought to proposing a 30 foot tower in the midst of 100 ft. trees. Such applications should be returned without further consideration, and without the right of petition for reconsideration. Personally, I go to great lengths to thoroughly engineer a station (Commission's rules permitting) such that its design is fully optimized and can be constructed as filed. I believe all applications should be engineered in this manner. Much greater restrictions on allowing a station to be moved would curtail many of the quickie, place-holder applications and would require thorough engineering be conducted before filing an application. But then, the way the Rules are convoluted and filing windows closed, repetitive filings are frequently a necessity.

15. ***Interference Criteria and Mutual Exclusivity.*** The basic formula for Received power level is pretty much intuitively obvious. I don't see a particular need to address it in the Rules. Why are you even concerned about it, seeing there are so many more pressing matters that need to be dealt with? Perhaps there has been confusion of which I am not aware. My only comment on the basic formula is that I prefer units that EIRP and RSL be expressed in dBm rather than dBW, as received power is generally expressed in those units. Conversion back and forth is quite easy, one need only add 30 to dBW to get dBm.

I would like to comment on the formula proposed for ($L_{FS}$). There is an equivalent format that is easier to work with in computer programs. The proposed format was:

$$(L_{FS}) = 20 \text{ Log } (4\pi d/\lambda)_{dB}. \qquad (1)$$

Why should the formula express distance in meters when the we normally work, and the Rules are expressed in miles? Why should the formula require wavelength ($\lambda$) when we normally think and work in terms of frequency (Gigahertz-GHz) or perhaps Megahertz (MHz)? Why not cut to the chase and express the formula in terms normally used in the industry and more convenient for computer programs? Why do the conversion over and over in software? I use a commercially available Radio Path Study program (recognized in the industry) supplied by EDX Engineering. It expresses Path Loss in the following format:

$$(L_{FS}) = 32.45 + 20 \text{ Log } (\text{Freq.}_{MHz}) + 20 \text{ Log } (\text{Distance}_{mi.}) \qquad (2)$$

This can be simplified to the following, equivalent, more suitable format:

$$(L_{FS}) = 96.5826 + 20 \text{ Log } (fd) \qquad (3)$$

where f is in GHz and d is in miles.

The above formulas, including the one proposed in the NPRM, are equivalent and give the same result. In the latter (3), the conversion factors are calculated once and included as a constant, rather than calculated zillions of times over by the software. If MHz is preferred, one only need change the constant from 96.5826 to 36.5826. I use this formula in several programs. All the formula need do is reference the distance calculation and the frequency (which is entered automatically when the channel group is entered). It is simple, accurate, straightforward and to the point.

Since reference was made to adopting the format for use with computerized analysis programs, I perhaps could comment further, as I have had a considerable amount of experience in this area. The approach in common use to calculate the D/U ratio is to calculate received power level of both the Desired and Undesired signals at the receive point, then subtract the Undesired from the Desired to derive the D/U ratio. In interference calculations, the received power level is of no relevance, only the difference between the two. It is more convenient in computerized studies to derive the D/U ratio directly. Instead of subtracting the calculated U received power level from the D received power level, the right hand side of the equations can be combined into one D/U equation. By simply subtracting the right hand side of the received power level equation for the U from the D received power level, a single D/U equation is derived. Solving this single equation then gives the D/U ratio directly, eliminating the need to solve two separate equations, then subtract one result from the other. This is a distinct advantage when using a spreadsheet program to compute interference analyses, as the D/U can be calculated in a single column, rather than three. Such a program to compute MMDS/ITFS studies is quite large, so anything that will reduce its size and complexity is an advantage. (Very elaborate and extremely accurate interference studies can be readily accomplished with a spreadsheet, including complete data entry menus and macros to accomplish automated operation. Such programs can be developed by the average engineer not having the skills necessary to do computer programming).

It follows that the D/U equation is:

$$D/U_{dB} = (D\ EIRP - U\ EIRP)_{dBm} - (DL_{FS} - UL_{FS})_{dB} + (\text{Antenna rejection of the U signal})_{dB}$$

(Or if you prefer, dBW, it matters not since they are a ratio and once subtracted the resultant EIRP ratio is expressed in dB whether EIRP is expressed in dBW or dBm). The absolute gain of the receive antenna is of no relevance, only the amount of rejection of the undesired signal in relation to the desired. By assuming the lobe of maximum gain to be normalized to unity, the U attenuation can be read directly from the antenna horizontal radiation pattern, from a lookup table, or better yet, precisely calculated by an equation that defines the antenna pattern. The D/U ratio column is then a simple summation of the U EIRP, D EIRP, U $L_{FS}$, D $L_{FS}$ and the receive antenna rejection of the U signal. Though these formulas can be combined further before solution, since each of the component values is required for a proper tabular listing of the study results (See Table 1, Exhibit B), it is not feasible to do so. Since I have considered these matters in minute detail, having developed a number of relatively sophisticated analysis programs over the past several years, I have a developed pretty good understanding of how to go about configuring programs and formulas to achieve the best and most simple implementation.

The RSL equation as stated in the NPRM is suitable for use in station design where it is necessary to calculate received rower level at receive sites, but the D/U equation is superior for interference analyses. So if adopting the equation as stated precludes using the D/U equation, then I oppose it. If allowing the proposed equation to be manipulated into the D/U equation form, then I have no opposition to it.

***Signal Contour Maps.*** Should the requirement be eliminated? (The comments in this section also pertain to how the Commission can expedite application processing as the methods described make application engineering much more rigorous, yet much easier for the Commission to evaluate). This I presume is referring to the 100 mile map rule. And I have quite a lot to say about it. With regard to the 100 mile map, I definitely concur that the signal contour requirements should be eliminated, as they are difficult to compute (i. e. the zero dB contour), difficult to plot with accuracy on a regular map and not very meaningful when so plotted. This is especially true for adjacent-channel stations. There is no technical merit, whatsoever, in requiring zero dB D/U contours for adjacent-channel stations, especially to a distance of 100 miles. At these distances they range in size from hundreds of miles to infinity, so cannot be easily calculated or plotted, nor do they serve any useful purpose. Indeed, there should not be a requirement to even *consider* adjacent channel stations located beyond 50 miles, as there is little potential for harmful interference to occur to stations located beyond 20 or 30 miles, even between stations of the same polarization. The conventional PSA-Perimeter analysis, conducted on a free space path loss basis, is the best method to evaluate the potential for harmful interference to adjacent channel stations located 20-25 or more miles apart, depending on the PSA shape.

With regard to co-channel stations, there is considerable merit to require consideration of the potential for harmful interference to stations up to 100 miles away. This was made abundantly clear in Paragraph 7. above. While the D/U contour is extremely useful in individual interference analyses, there is no merit to plotting such a contour of co-channel stations located within 100 miles on a "map" of unspecified dimensions. It should be kept clearly in focus that anything pertaining to the 100 mile map should be specifically oriented toward ***identifying*** stations that need to be included in the detailed analysis, and not toward indicating whether harmful interference will occur. The proper way to consider the potential for harmful interference to co-channel stations located up to 100 miles away is prepare a 100 mile shadow map (30 sec terrain database) and observe how far unobstructed electrical paths occur. Add 25 miles to this value and conduct a database/Inventory List search to that radius. Then plot the protected service areas of all such co-channel stations on the shadow map. This identifies stations beyond 50 miles into which there exists unobstructed electrical paths. Such identified stations require detailed analysis. If terrain shielded, they don't, it is as simple as that, and a determination can be made at a glance. (Since the Rules require analysis of co-channel stations closer than 50 miles, nothing is gained by plotting them on the shadow map). This gives the Commission (and the engineer preparing the analysis) a graphical display to quickly see precisely which stations need to be included in the detailed analysis and which don't. This will simplify applications by eliminating needless studies, while assuring that stations that need study indeed are studied. So, retaining portions of the 100 map rule would be appropriate. In summary, this should be accomplished by replacing the "map" with a 100 (or 125) mile radius *shadow map*, retaining the plotted PSAs and eliminating the D/U contour requirements.

This procedure *considers* all co-channel stations located within 100 miles by virtue of demonstrating that those beyond a certain distance are terrain shielded; it examines those within the database search radius to see whether they are terrain shielded and identifies those with unobstructed electrical paths into their PSA such that they are included in the detailed analysis. Since those located closer than 50 miles are included in any case, it follows that the procedure *considers all stations located within 100 miles of a proposed station.*

It is relatively straightforward to configure a spreadsheet program to run automatically, importing antenna pattern files as required, calculating and saving PSA plot files that can readily be merged into the shadow map program with a simple batch type command. Such an approach assures a high degree of precision in locating the PSA plots by utilizing the precise plotting capabilities of the shadow map program. Such a PSA/Shadow map can be prepared very quickly, about five or ten minutes to run the shadow map and about the same time to accomplish the rest. An example is shown in Appendix A. Since this is such a informative, yet easily accomplished and easy to evaluate method to identify stations that need to be studied and to eliminate those that do not, it should be adopted as an application requirement.

**The Proper Use of D/U Signal Contours.** The D/U contour is such a powerful analysis tool that, rather than toss it out entirely, its intended use should be properly recognized and stated such that something useful is accomplished with it. When the D/U contour and the PSA are both plotted on the shadow map (or a shadow map segment), a very powerful analysis technique emerges. It conducts and displays in a graphical, easy to be understood format, a very precise and detailed area wide interference analysis that, not only demonstrates whether harmful interference will or will not occur, but precisely *where* it will occur, both within and beyond the PSA. And it accomplishes this at a glance. The D/U contour encompasses the area where harmful interference will not occur, as calculated on a free space path loss basis, under any circumstances, while the shadow map displays terrain shielding afforded by topography and the PSA delineates the area of concern. So all one need do to evaluate an analysis is observe whether the area outside the D/U contour and within the PSA (the API) is terrain shielded. If so, then harmful interference, as defined by the Commission, will not occur. A study result can be evaluated in the time it took to read the previous sentence. The method is far superior to the inadequate, though commonly used PSA-Perimeter study technique. It neatly encompasses both ends of the spectrum by providing more rigorous analyses in an extremely easy to evaluate format. So, I don't recommend that D/U signal contour requirements be eliminated, rather I propose that their true utility be recognized and that their proper use be adopted. And this is in individual *co-channel* studies to precisely identify areas of harmful interference (or more precisely to demonstrate the lack of harmful interference), rather on a "map" *or* the 100 mile shadow map. The method is also very useful in closely spaced *adjacent-channel* stations where the PSA-Perimeter study indicates the presence of harmful interference. It also is of considerable value in real world station optimization. Such improved techniques will assure that better station design is accomplished, therefore harmful interference will be reduced. This will enure to everyone's benefit. Since a more rigorous method exists that is easy for the Commission to evaluate and is readily attainable by competent engineers, why not take advantage of the method to reduce the burden of application processing by virtue of study results that are extremely easy to evaluate, and will result in better station design and consequently reduced harmful interference as a side benefit. An example of the technique is shown in Appendix B.

16. ***Improvement of 494 form and elimination of certain technical specifications.*** I don't have any disagreement with anything proposed in this paragraph, except I might add that it would really be nice if the hard copy form could be issued in software, say on a floppy or from a bulletin board in a format that would allow it to be loaded into a computer, filled out and printed on a laser printer in one pass. It's really a pain to keep all the little 'x' s in the little boxes on the present form. At least make the little boxes a bit larger. Also, the narrative regarding the public interest perhaps could be modified to require certification that the station is situated in such a manner that its primary service area cannot be adequately served by any authorized, or previously proposed station, and that it is located and engineered such that it will serve the intended area and that a sufficient number of subscribers can be served to make it an economically viable station. This perhaps would minimize frivolous applications, or at least give the Commission legal grounds to dismiss those that misrepresent the need of, or viability of a proposed station.

17. ELECTRONIC FILING/SHORT FORM INITIAL APPLICATIONS - With the majority of areas/channels already applied for or granted, it seems a bit late in the game to consider changing to the short form/electronic filing approach, as most likely a large percentage of legitimate future applications will be amendments or modifications to optimize and collocate existing or previously proposed MMDS and ITFS stations. This is not addressed in the NPRM, however, is a point that should weigh heavily in any decision made. It is presumed that amendments and modifications will continue to be handled as usual. If indeed this is an accurate assessment, then little would be gained by adopting the new procedures, indeed coordinating the two may likely present another level of complication. Paragraph 5 of the NPRM states that "we believe that accelerated processing permitted by electronic filing and data collection, along with competitive bidding procedures, will reduce the likelihood of speculative filings and generally expedite the initiation of new service'. I am not convinced this will be the case. If MMDS application requirements are reduced to filing a simple, short form initial application, I suspect that the application mills will again become active, filing frivolous applications in every nook and cranny in the country, whether a viable market or not, in hopes that they may find a small niche where no one else was clever enough to have filed, all the while not really caring whether successful or not, once the hefty commissions have been paid. It is not likely that such

entitiewould have an interest in bidding for licenses, rather would perceive it as an opportunity to extract greenmail (to simply go away) from legitimate operators. Yet, on the other hand, it may introduce another opportunity for the more creative mills to contrive new strategies to entice Ma and Pa investors. Here, the pitch would likely be that they were amassing a large pool of monies with which to bid on licenses in the lotteries. Well known is the fact that the majority of monies raised in such schemes generally ends up in someone's pocket with very little going into the intended project. If successful in acquiring a license, whether economically viable or not, what another great opportunity to raise even greater amounts of cash from Ma and Pa to ostensibly 'build a station'. I do not believe the entire proposal is in the public interest, as I do not believe it will it solve the problem of expediting application processing. Rather than discourage, I suspect it will encourage application mills to get back into the fray. Accordingly, I do not believe it should be adopted.

20. *Electronic Filing* - The NPRM states that "we envision a windows-based environment". Why is that? Data is data. Why not just specify a de-facto database standard such as dBase III+. Most database, spreadsheet and word processing programs will import/export data in that format. All that need be done is to standardize the format by assigning field names and perhaps field size to certain fields. Data can be entered from a computer operating in DOS or windows environment, then downloaded into either a DOS or windows environment. I don't do windows, I hate windows, windows suck, I run DOS. Windows puts unreasonable demands on the computer hardware, all the while creating a slow, unstable, crash prone operating environment suitable for desk top publishing or graphics, but of little utility for communications engineering. Besides, all engineering software, at least that with which I am familiar and use, runs in DOS. Number crunchers who want to get the job done generally resort to their favorite DOS programs. Windows is a big enough pain to run without having to switch back and forth between DOS and windows. So please don't lay a windows based operating environment requirement on us. Adopt a standard that is portable between DOS and windows, if windows is what you want to run.

Graphics can easily be handled in a standardized format without the unstable windows environment. Engineering software used for MMDS studies (or drafting programs for drawings, if required) save graphical information such as shadow maps, Radio Path Studies, etc. in a standard HPGL (Hewlett Packard Graphics Language) format, another de-facto standard. A program that costs 129 bucks (or an available shareware program) will translate HPGL files into a raster format that can be viewed on screen or printed on a Laser Jet compatible printer adhering to the HP PCL4 or PCL5 standard. These standards have evolved over years of development and communications software development companies recognize them and configure their programs to prepare these type of output files.

Since engineers generally prepare applications, they logically would be the primary transmitters of such electronic filing rather than VANs as suggested. So why not adopt a format that is compatible with the considerable amount of software engineers have purchased (and this can easily be $5,,000 - $10,000 worth) and have at their disposal, configured such that they can readily transmit files that are customarily used in the industry. Such files are, by their very nature are in a format with which Commission engineers are familiar and could readily use. The graphics pages (except for the labeling) in Appendices A & B are generated in HPGL format. Perhaps Word Perfect 5.1 would be a good standard for text.

As far as transmittal is concerned, if the Commission insists on electronic filing directly into a central computer, why not make it so a standard modem merely need transmit a files such as described above into the computer. Alternately, they could be put on a 29¢ floppy and dropped into the envelope with other required hard copy exhibits, fees, etc.

**GENERAL COMMENTS** - Regarding the Commission's plans to develop a grandiose, be-all, end-all software program that will accurately determine exclusivity (which implies the ability to consider in minute detail all parameters required to quantify harmful interference, including terrain considerations) for a large batch of applications filed across the country, I have a considerable amount of skepticism. I have had enough experience to know that software development is never accomplished on time, never on budget and always requires lengthy debugging. In order to develop such a program in any reasonable length of time would likely require simplifying assumptions that would greatly compromise the program's ability to adequately perform its intended task. In short, I am not convinced that such a program will be the be-all, end-all answer to the Commission's processing problems, rather, I suggest that it will likely delay processing and/or will perform its task inadequately due to simplifying assumptions that likely will be made. Such simplifying assumptions may serve to be overly conservative and prohibit many stations that are needed, or perhaps authorize others that will interfere, depending on the simplifying assumptions made. So, in summary, I am not in favor of the proposal of adopting a short form initial application with the hope that the Commission has the ability to adequately perform a sufficiently detailed interference analyses. The electronic filing would logically be inappropriate if the short form approach is not adopted.

Serving the Public Interest will not be accomplished by authorizing the maximum number of MMDS stations, or collecting the greatest amount of dollars from license auctions, rather will be served by providing interference free service to the maximum number of subscribers. This can best be accomplished through careful engineering conducted in the private sector using advanced interference analysis techniques. In determining the winner in mutual exclusive applications, preference should be given to stations that are proposed in areas that are best suited for an MMDS station. This can easily be determined by examining a signal coverage plot of surrounding MMDS stations. It is usually intuitively obvious whether one or two, or perhaps three stations are required to cover unserved areas in between existing MSAs. Proposed stations that are rigorously engineered and demonstrate that they best serve the public interest, best integrate into serving an area with existing stations and are engineered to best coexist with the pattern of stations appropriate to serve a given area should be given preference over marginally engineered or inappropriately located stations. This approach would serve the public interest better than the auction process. Since it is incumbent on the Commission to serve the public interest first, it should use auctions as a last resort, rather as a money raising scheme.

I firmly believe that the Commission's resources would be best be deployed in adopting a coherent set of rules, including interference rules, that, firstly, are consistent for all MDS, MMDS and ITFS channels, secondly, utilize more rigorous interference analysis techniques than currently in common use, thirdly, requires analyses to follow a consistent format, and fourthly, requires study results to be presented in a format that is very easy for the Commission to quickly evaluate. Such a procedure that neatly accomplishes all these goals has been fully developed and is included in the Appendices for reference. These techniques are presented as an example to illustrate that, when presented in the proper format, that MMDS studies need not be an overly burdensome task for the Commission to evaluate. An interference analysis vs several neighboring stations presented in such a format can be evaluated in minutes rather than hours or days, once the surrounding station information has been verified.

Additionally, if proposals to grant all available E, F and H licenses to one entity (perhaps to an existing licensee) are adopted, the builder/operator should be required to specify in his application the specifications of his pertinent transmit parameters (coordinates, antenna elevation, antenna pattern/orientation, polarization and EIRP) at which he intends to operate the facility. Any channels intended to be used in the station that have differing parameters could then be ignored in interference analyses. This would allow newly proposed neighboring stations (perhaps also for all available MMDS channels) to file only one interference analysis that would apply to all channels applied for. In other words the analyses would be conducted against stations, rather than individual channel groups unless there is another user on certain channels who does not intend to become part of the station. This would expedite the development of MMDS and would minimize the number of analyses the Commission would have to review. Of course the odd channel here or there that for whatever reason, is not, or will not be a part of the station, it would have to be studied separately, but this would be an occasional exception.

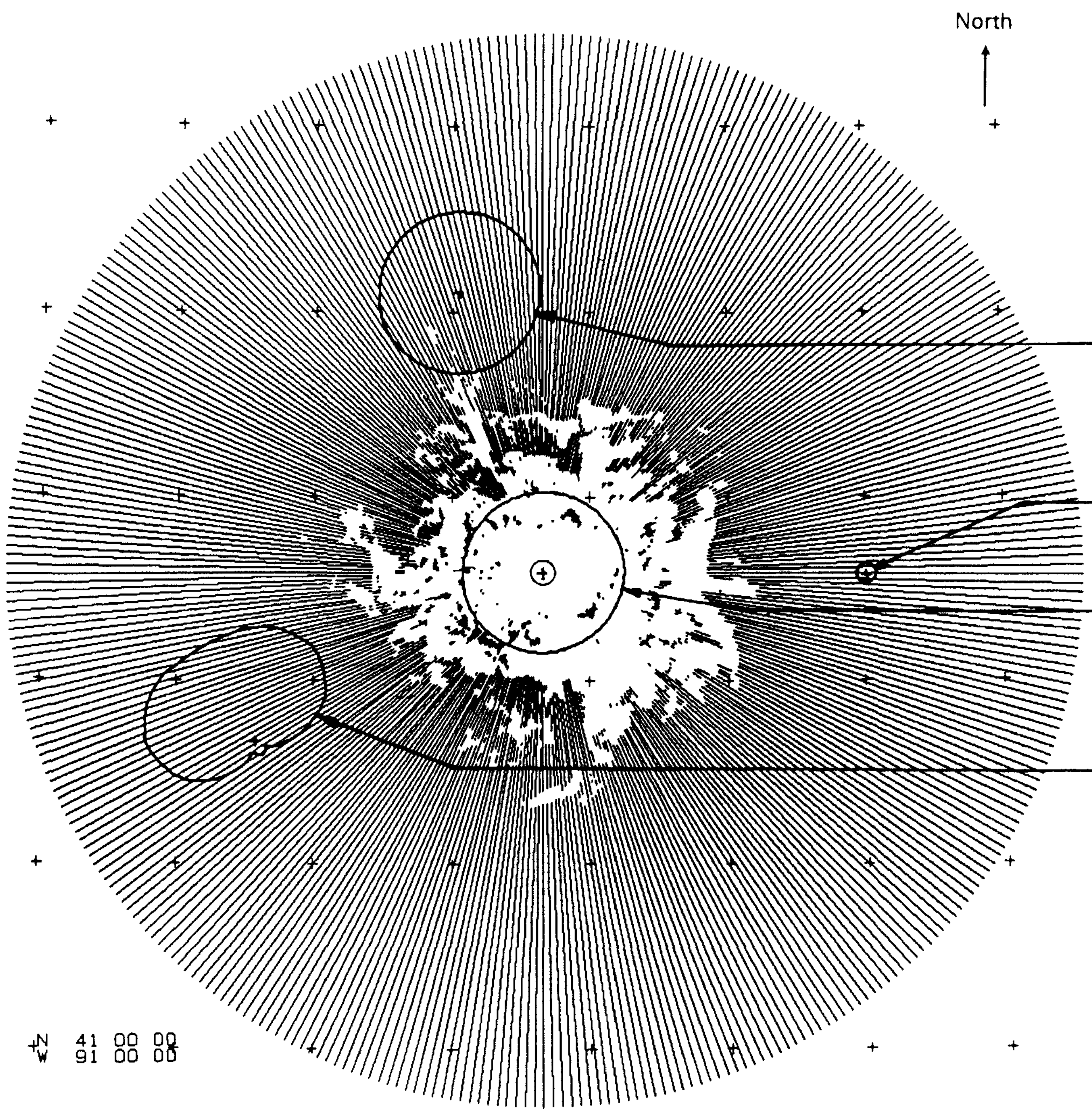
Overall, I would have to say that I am far less enamored with the electronic filing approach than apparently the Commission is. Nor am I at all convinced that the grandiose be-all end-all computer program exists, or will exist in a reasonable amount of time, or will suitably accomplish its required task when, and if, completed. I suspect that getting it up and going will result in another year or so of delay while the MMDS world languishes. Please release a status report on how the Commission intends to develop such a program, upon what principles will it operate to determine interference, what simplifying assumptions have been made, what has been accomplished to date and when will it be completed and debugged.

Daniel J. Marshall

Daniel J. Marshall, President

## APPENDIX A

Example of the 100 mile radius shadow map with co-channel PSAs plotted. Note that this is a simple example to illustrate the principle. Some stations have many more surrounding stations, some with substantial amounts of unobstructed electrical paths into PSAs. It is in such complex situations as these that benefit most from the technique.




RADIO SHADOW MAP

K Factor: 1.330

RX Ant. Height: 30.0 feet AGL

| Site | Ant Elv AMSL (feet) | ERPd (dBW) | Ant. Type | Ant. Orient (degs) | Latitude & Longitude |
|---|---|---|---|---|---|
| 1 | 1268.0 | 17.70 | OMNI | | N 42 17 48<br>W 89 10 15 |

MILES

20 0 20 40 60

# Rockford, IL

100 mi ShdMap & F Co-chnl PSAs

January 21. 1994 Figure 1

Marshall Communications, Inc.



F1-F4

## APPENDIX B

Example of a computerized co-channel MMDS interference analysis employing both the PSA-Perimeter study method and the 'Shadow map Wedge-PSA-45 dB D/U Contour' technique. The Rpath plots referenced in the PSA-Perimeter study have been ommitted for brevity. As in Appendix A, this is also a very simple example to illustrate the principle. When neighboring stations are much closer, with substantial areas of unobstructed electrical paths into the PSA, the the SM Wedge-PSA-Contour technique demonstrates its true capabilities.

## MMDS CO-CHANNEL INTERFERENCE ANALYSIS

Proposed Station vs WHT772

| | Undesired Station: | Desired Station: |
|---|---|---|
| Station Call Letters: | WMI326 | WHT772 |
| FCC Appl. File number: | 53324-CM-MP-92 (last) | 50246-CM-L-89 |
| Station Location: | Rockford, IL | Madison, WI |
| Transmit Coordinates: | 42-17-48N 89-10-15W | 43-03-18N 89-28-42W |
| Dist./Azmth. from "U" Sta.: | | 54.7 miles @ 343.5 degrees |
| Channels (Proposed/Auth): | F1-F4 | F1-F4 |
| Licensee/Applicant (Name): | Multi-Micro, Inc. | Skyview, Inc. |
| Freq. Stability & Req. D/U: | ±1.0 kHz | 45 dB |
| Tx Antenna (mfg, model): | Andrew HMD12HO-W | Bogner B16SO |
| Tx Polarization/Pattern: | Horizontal/Omni | Vertical/Omni |
| Tx Orientation: | 0.0 degrees | 0.0 degrees |
| Tx Antenna Elevation, AMSL: | 1268.0 feet (386.5m) | 1650.0 feet (502.9m) |
| Tx Antenna Height, AGL: | 450.0 feet (137.2m) | 600.0 feet (182.9m) |
| Tx Power: | 40.0 dBm (10 watts) | 40.0 dBm (10 watts) |
| Tx Line & Combiner Loss: | 5.3 dB | 6.0 dB * |
| Tx Antenna Gain (@GMax): | 13.0 dBi | 14.0 dBi |
| EIRP (Gmax): | 47.7 dBm (58.9 watts) | 48.0 dBm (63.1 watts) |

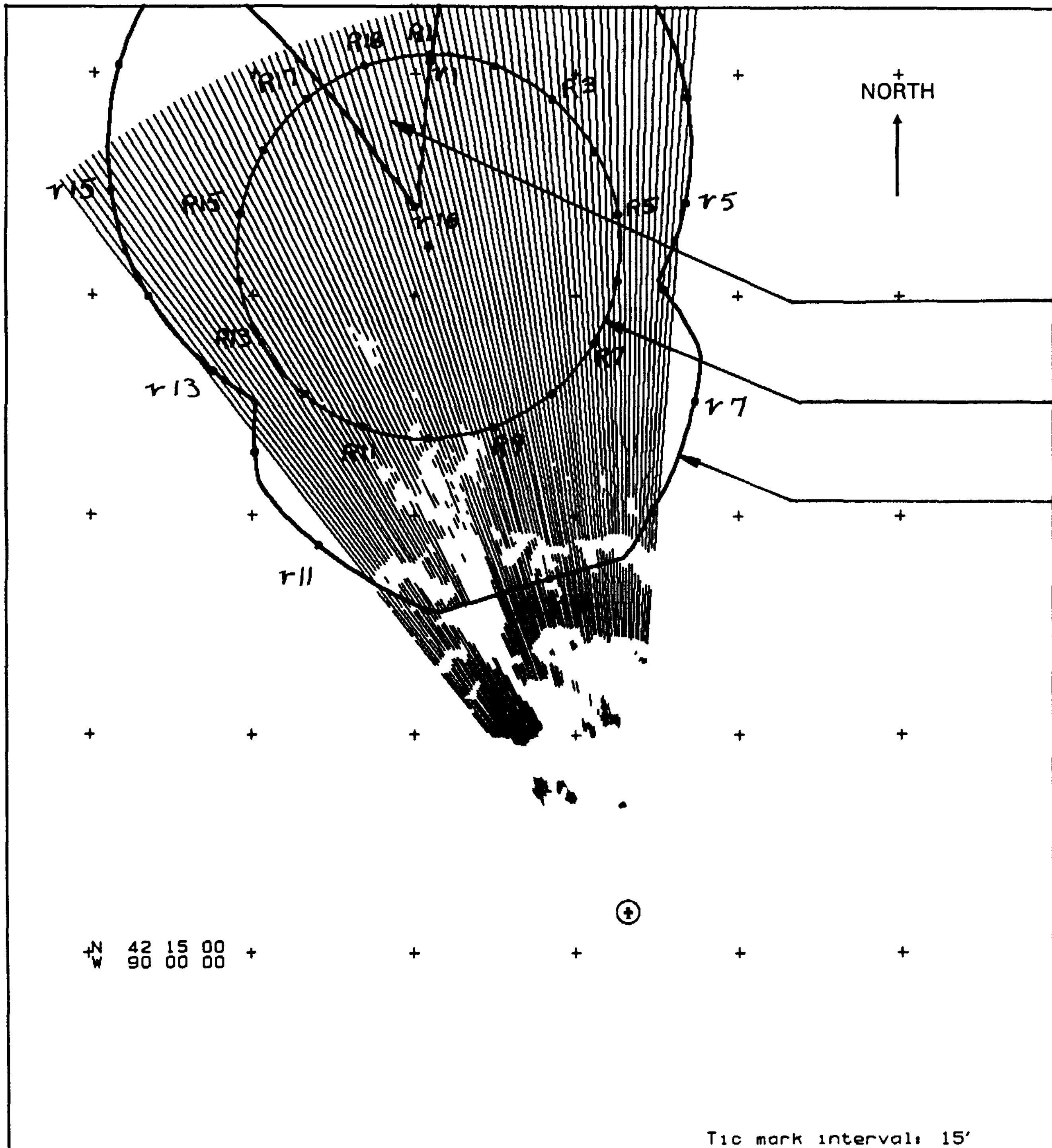
* Assumes same combiner losses as WMI326 + .43 dB/100 ft. waveguide loss

An interference analysis was conducted to determine the potential for harmful interference to the operations of WHT772 from the herein proposed station. The D/U ratio of interfering signals from the herein proposed station to various receive sites of station WHT772 was derived and compared to the Commission's definition of harmful interference defined in 47 CFR §21.902(b)(3) for MMDS stations operating on the same channels, 45 dB. The analysis was conducted in accordance with the Commission's Rules as described in Exhibit E proper utilizing the radiation envelope pattern of the FCC Reference Receive Antenna defined in 47 CFR §21.902(f)(3)(Figure 1), taking into account the polarization of the respective transmit signals.

Table 1 lists the results of a PSA-Perimeter analysis conducted at 18 assumed receiving points spaced at 20 degree intervals on the perimeter of WHT772's PSA. Terrain attenuation of the interfering signal is included at studied points where free space path loss calculations predict less than the required D/U ratio. Each of the eighteen points demonstrate the absence of harmful interference.

Figure 1 shows the results the more rigorous 'Shadow Map Wedge-PSA-D/U Contour' analysis technique. It consists of the PSA of WHT772 and the D/U contour precisely plotted upon a shadow map segment from the herein proposed station; calculations are on a free space path loss basis. Harmful interference will occur in areas where unobstructed electrical paths exist from the herein proposed station into the *area of potential interference* (API), i. e. the area *outside* the D/U contour and *inside* the PSA. Since the shadow map demonstrates terrain blockage of signals from the proposed station throughout the API, it can be concluded that harmful interference will not occur to the operations of WHT772 from the herein proposed station. Data pertaining to the 18 marker points on the D/U contour are shown in Table 2.

In the event that signals from WMI326 cause harmful interference to the operations of WHT772, Applicant pledges to take such corrective actions as necessary to maintain the required 45 dB D/U ratio.




RADIO SHADOW MAP

K Factor: 1.333
RX Ant. Height: 30.0 feet AGL

| Site | Ant Elv AMSL (feet) | ERPd (dBW) | Ant. Type | Ant. Orient (degs) | Latitude & Longitude |
|---|---|---|---|---|---|
| 1 | 1268.0 | 17.70 | OMNI | | N 42 17 48<br>W 89 10 15 |

Area of Potential Interference

PSA - WHT772 (F1-F4)

45 dB D/U contour

Note: See Page 1 for Station parameters used in the analysis.

MILES

10 0 10 20

WMI326 vs WHT772

ShdMap, PSA & 45 dB D/U Contour

February 15, 1994 Figure 1



F1-F4

## MMDS CO-CHANNEL INTERFERENCE ANALYSIS

WMI326 vs Protected Service Area of WHT772

Table 1 below is a PSA-Perimeter interference analysis conducted from the herein proposed station to eighteen equally spaced points on the PSA perimeter of WHT772. See Figure 1. Internal values are used for calculations; the "Total D/U Ratio" column may vary slightly from the rounded values displayed.

| Rec. Site no. | Receive Site Coordinates North Latitude | Receive Site Coordinates West Longitude | Angle from "D" TxAnt Gmax (deg) | Angle from "U" TxAnt Gmax (deg) | (1) "D" EIRP to Rx (dBm) | (2) "U" EIRP to Rx (dBm) | Dist. Rx to "U" Tx (mi) | (3) "U" Free Space Path Loss (dB) | Dist. Rx to "D" Tx (mi) | (4) "D" Free Space Path Loss (dB) | (5) Excs "U" Path Loss (dB) | Rx to "D" Tx Azmth (deg) | Rx to "U" Tx Azmth (deg) | Angle of "U" Signl to Rx Ant (deg) | Rec. Ant. Model Used In Study | (6) Rec. Ant. Sel. (d/u) (dB) | (7) Rec. Ant. Pol. Disc. (XPD) (dB) | (8) Tot. D/U Rat. (dB) | Harmful Interference ? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 43 16 20 | 89 28 42 | 0.0 | 347.1 | 48.0 | 47.7 | 69.2 | 141.7 | 15.0 | 128.5 | 35.0 | 180.0 | 166.9 | 13.1 | FCC Ref | 12.3 | 18.6 | 79.4 | No |
| R2 | 43 15 32 | 89 22 36 | 20.0 | 351.1 | 48.0 | 47.7 | 67.3 | 141.5 | 15.0 | 128.5 | | 200.0 | 171.0 | 29.0 | FCC Ref | 15.7 | 20.3 | 49.3 | No |
| R3 | 43 13 17 | 89 17 14 | 39.9 | 354.8 | 48.0 | 47.7 | 64.2 | 141.1 | 15.0 | 128.5 | | 220.1 | 174.7 | 45.4 | FCC Ref | 20.0 | 16.0 | 48.9 | No |
| R4 | 43 9 49 | 89 13 16 | 59.9 | 357.6 | 48.0 | 47.7 | 59.9 | 140.5 | 15.0 | 128.5 | | 240.1 | 177.5 | 62.5 | FCC Ref | 20.0 | 16.0 | 48.3 | No |
| R5 | 43 5 34 | 89 11 9 | 79.9 | 359.2 | 48.0 | 47.7 | 55.0 | 139.8 | 15.0 | 128.5 | | 260.1 | 179.2 | 80.9 | FCC Ref | 20.0 | 16.0 | 47.6 | No |
| R6 | 43 1 2 | 89 11 9 | 99.9 | 359.1 | 48.0 | 47.7 | 49.8 | 138.9 | 15.0 | 128.5 | | 280.1 | 179.1 | 101.0 | FCC Ref | 18.1 | 19.7 | 48.6 | No |
| R7 | 42 56 47 | 89 13 16 | 119.9 | 356.8 | 48.0 | 47.7 | 45.0 | 138.0 | 15.0 | 128.5 | | 300.1 | 176.7 | 123.4 | FCC Ref | 21.4 | 20.2 | 51.5 | No |
| R8 | 42 53 19 | 89 17 14 | 139.9 | 351.8 | 48.0 | 47.7 | 41.3 | 137.3 | 15.0 | 128.5 | | 320.1 | 171.7 | 148.3 | FCC Ref | 25.0 | 20.0 | 54.1 | No |
| R9 | 42 51 4 | 89 22 36 | 160.0 | 344.8 | 48.0 | 47.7 | 39.7 | 136.9 | 15.0 | 128.5 | | 340.0 | 164.6 | 175.4 | FCC Ref | 25.0 | 20.0 | 53.8 | No |
| R10 | 42 50 16 | 89 28 42 | 180.0 | 337.4 | 48.0 | 47.7 | 40.5 | 137.1 | 15.0 | 128.5 | | 0.0 | 157.2 | 157.2 | FCC Ref | 25.0 | 20.0 | 53.9 | No |
| R11 | 42 51 4 | 89 34 48 | 200.0 | 331.6 | 48.0 | 47.7 | 43.6 | 137.7 | 15.0 | 128.5 | | 20.0 | 151.3 | 131.4 | FCC Ref | 22.6 | 20.2 | 52.3 | No |
| R12 | 42 53 19 | 89 40 10 | 220.1 | 328.4 | 48.0 | 47.7 | 48.1 | 138.6 | 15.0 | 128.5 | | 39.9 | 148.0 | 108.1 | FCC Ref | 19.2 | 20.4 | 50.0 | No |
| R13 | 42 56 47 | 89 44 8 | 240.1 | 327.6 | 48.0 | 47.7 | 53.3 | 139.5 | 15.0 | 128.5 | | 59.9 | 147.2 | 87.3 | FCC Ref | 18.0 | 18.0 | 47.3 | No |
| R14 | 43 1 2 | 89 46 15 | 260.1 | 328.7 | 48.0 | 47.7 | 58.4 | 140.3 | 15.0 | 128.5 | | 79.9 | 148.3 | 68.4 | FCC Ref | 20.0 | 16.0 | 48.1 | No |
| R15 | 43 5 34 | 89 46 15 | 280.1 | 331.2 | 48.0 | 47.7 | 62.9 | 140.9 | 15.0 | 128.5 | | 99.9 | 150.8 | 50.9 | FCC Ref | 20.0 | 16.0 | 48.7 | No |
| R16 | 43 9 49 | 89 44 8 | 300.1 | 334.6 | 48.0 | 47.7 | 66.4 | 141.4 | 15.0 | 128.5 | | 119.9 | 154.2 | 34.3 | FCC Ref | 17.4 | 18.6 | 49.2 | No |
| R17 | 43 13 17 | 89 40 10 | 320.1 | 338.6 | 48.0 | 47.7 | 68.7 | 141.7 | 15.0 | 128.5 | | 139.9 | 158.2 | 18.3 | FCC Ref | 16.0 | 20.0 | 49.5 | No |
| R18 | 43 15 32 | 89 34 48 | 340.0 | 342.8 | 48.0 | 47.7 | 69.7 | 141.8 | 15.0 | 128.5 | 38.5 | 160.0 | 162.5 | 2.6 | FCC Ref | 0.0 | 20.0 | 72.1 | No |

The "Total D/U Ratio (dB)" = EIRP ratio (d/u) + FSPL ratio (u/d) + Terrain Atten. of the "U" signal + Rec. Ant. Characteristics (d/u)
= ("D" EIRP - "U" EIRP) + ("U" FSPL - "D" FSPL) + Excess Path Loss + (Rec Ant. Selectivity + Rec Ant XPD)
(8) = (1)-(2)+(3)-(4)+(5)+(6)+(7)

Plots of the Radio Path Loss Studies (predicting the terrain loss of the interfering signal), when claimed in the analysis, are appended.

Table 1

## MMDS CO-CHANNEL INTERFERENCE ANALYSIS

D/U Contour - WMI326 vs WHT772

Table 2 (below) is eighteen of the 180 solutions of the D/U contour equation that define the D/U contour plot in Figure 1. They are arbitrarily situated at the same equally spaced angular intervals as the PSA-Perimeter study points. R1 from the PSA-Perimeter study and r1 from the D/U contour are always in the same direction as the "D" antenna orientation ("D" $G_{max}$) for directional antennas and always North when the "D" transmit antenna is omni-directional.

| Rec. Site no. | Receive Site Coordinates North Latitude | West Longitude | Angle from "D" TxAnt Gmax (deg) | Angle from "U" TxAnt Gmax (deg) | (1) "D" EIRP to Rx (dBm) | (2) "U" EIRP to Rx (dBm) | Dist. Rx to "U" Tx (mi) | (3) "U" Free Space Path Loss (dB) | Dist. Rx to "D" Tx (mi) | (4) "D" Free Space Path Loss (dB) | Rx to "D" Tx Azmth (deg) | Rx to "U" Tx Azmth (deg) | Angle of"U" Signl to Rx Ant (deg) | Rec. Ant. Model Used In Study | (5) Rec. Ant. Sel. (d/u) (dB) | (6) Rec. Ant. Pol. Disc (XPD) (dB) | (7) Tot. D/U Rat. (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r1 | 43 15 48 | 89 28 42 | 0 | 346.9 | 48.0 | 47.7 | 68.6 | 141.7 | 14.39 | 128.1 | 180.0 | 166.7 | 13.3 | FCC Ref | 12.5 | 18.7 | 45.1 |
| r2 | 43 26 57 | 89 16 55 | 20 | 355.9 | 48.0 | 47.7 | 79.8 | 143.0 | 28.99 | 134.2 | 200.1 | 175.9 | 24.2 | FCC Ref | 16.0 | 20.0 | 45.1 |
| r3 | 43 20 50 | 89 8 34 | 40 | 1.0 | 48.0 | 47.7 | 72.6 | 142.2 | 26.36 | 133.4 | 220.1 | 181.1 | 39.1 | FCC Ref | 19.3 | 16.7 | 45.1 |
| r4 | 43 13 25 | 89 4 42 | 60 | 4.1 | 48.0 | 47.7 | 64.2 | 141.1 | 23.32 | 132.3 | 240.1 | 184.1 | 56.0 | FCC Ref | 20.0 | 16.0 | 45.1 |
| r5 | 43 6 22 | 89 4 51 | 80 | 4.5 | 48.0 | 47.7 | 56.1 | 139.9 | 20.37 | 131.1 | 260.1 | 184.6 | 75.6 | FCC Ref | 20.0 | 16.0 | 45.1 |
| r6 | 43 0 30 | 89 6 54 | 100 | 3.1 | 48.0 | 47.7 | 49.2 | 138.8 | 18.62 | 130.3 | 280.1 | 183.2 | 96.9 | FCC Ref | 18.0 | 18.4 | 45.1 |
| r7 | 42 52 53 | 89 4 0 | 120 | 7.2 | 48.0 | 47.7 | 40.7 | 137.1 | 23.99 | 132.6 | 300.1 | 187.3 | 112.8 | FCC Ref | 19.9 | 20.3 | 45.1 |
| r8 | 42 45 14 | 89 7 57 | 140 | 3.3 | 48.0 | 47.7 | 31.6 | 135.0 | 27.15 | 133.6 | 320.1 | 183.3 | 136.8 | FCC Ref | 23.4 | 20.1 | 45.1 |
| r9 | 42 40 42 | 89 17 26 | 160 | 346.9 | 48.0 | 47.7 | 27.1 | 133.6 | 27.70 | 133.8 | 340.1 | 166.8 | 173.2 | FCC Ref | 25.0 | 20.0 | 45.1 |
| r10 | 42 38 30 | 89 28 42 | 180 | 326.9 | 48.0 | 47.7 | 28.5 | 134.0 | 28.56 | 134.1 | 0.0 | 146.7 | 146.7 | FCC Ref | 24.8 | 20.0 | 45.1 |
| r11 | 42 42 58 | 89 38 50 | 200 | 320.4 | 48.0 | 47.7 | 37.7 | 136.5 | 24.91 | 132.9 | 19.9 | 140.0 | 120.1 | FCC Ref | 20.9 | 20.3 | 45.1 |
| r12 | 42 49 18 | 89 44 47 | 220 | 321.4 | 48.0 | 47.7 | 46.5 | 138.3 | 21.06 | 131.4 | 39.9 | 141.0 | 101.1 | FCC Ref | 18.2 | 19.8 | 45.1 |
| r13 | 42 54 51 | 89 48 44 | 240 | 322.9 | 48.0 | 47.7 | 53.6 | 139.5 | 19.47 | 130.7 | 59.9 | 142.5 | 82.6 | FCC Ref | 18.0 | 18.0 | 45.1 |
| r14 | 42 59 56 | 89 54 47 | 260 | 322.5 | 48.0 | 47.7 | 61.4 | 140.7 | 22.28 | 131.9 | 79.9 | 142.0 | 62.2 | FCC Ref | 20.0 | 16.0 | 45.1 |
| r15 | 43 7 7 | 89 58 22 | 280 | 324.7 | 48.0 | 47.7 | 69.8 | 141.8 | 25.34 | 133.0 | 99.8 | 144.2 | 44.4 | FCC Ref | 20.0 | 16.0 | 45.1 |
| r16 | 43 15 32 | 89 57 42 | 300 | 329.2 | 48.0 | 47.7 | 77.6 | 142.7 | 28.17 | 133.9 | 119.8 | 148.7 | 28.8 | FCC Ref | 16.7 | 19.3 | 45.1 |
| r17 | 43 23 25 | 89 51 48 | 320 | 335.3 | 48.0 | 47.7 | 83.3 | 143.4 | 30.25 | 134.6 | 139.9 | 154.9 | 15.0 | FCC Ref | 16.0 | 20.0 | 45.1 |
| r18 | 43 6 1 | 89 30 3 | 340 | 343.3 | 48.0 | 47.7 | 58.0 | 140.2 | 3.34 | 115.4 | 160.0 | 163.1 | 3.1 | FCC Ref | 0.0 | 20.0 | 45.1 |

The "Total D/U Ratio (dB)" = EIRP ratio (d/u) + FSPL ratio (u/d) + Receive Antenna Characteristics (d/u)
= ("D" EIRP - "U" EIRP) + ("U" FSPL - "D" FSPL) + (Receive Ant. Selectivity + Receive Ant. XPD)
(7) = (1)-(2)+(3)-(4)+(5)+(6)

Attenuation of the "U" signal from terrain shielding losses is not included in the D/U contour calculations.

Table 2